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A foggy start:

Determining the effect of eyewear fogging on visual task performance

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Abstract

To evaluate the effect of fogging of eyewear on task performance and to assess the effectiveness of an anti-fog coating, nine participants completed a visual search task under conditions simulating the two most likely occurrences of eyewear fogging. In the static environment, participants performed a visual search task while seated in front of a computer terminal. The eyewear was cold soaked in a cooler prior to being donned to simulate moving from a cold exterior to a warm interior environment. In the exercise environment, simulating exercising in the cold, participants performed the task in a cooled climatic chamber while pedaling a cycle ergometer. In this environment the eyewear was not cold soaked but was donned prior to entering the chamber. All participants performed the visual search task in static and exercise environments under three conditions: wearing no eyewear (bare-eye), wearing eyewear that had been treated with an anti-fog coating (coated eyewear) and wearing eyewear that had not been treated with anti-fog coating (uncoated eyewear).

Each condition was video recorded and participants' subjective evaluations of the degree of fogging were collected at regular intervals throughout the task. Accuracy and speed of response were collected as performance measures on the visual search task.

In the static environment fogging occurred on the uncoated eyewear immediately after it was removed from the cooler and continued for up to two minutes into the visual search task. Coated eyewear also fogged on six of the nine participants but for a much shorter period of time. Participants were significantly more accurate in performing the task while in the bare-eye and coated eyewear conditions compared to the uncoated condition. No effect of response time was evident but slowest responses were observed in the bare-eye condition. It is proposed that practice in performing the task was a contributing factor in this finding.

In the exercise environment build-up of fog on the lenses began at an average of eight minutes into the task. On the uncoated eyewear fogging was readily apparent but on the coated eyewear a thin water-film occurred on the lenses rather than fogging. Mean task accuracy was highest and mean response time fastest in the bare-eye condition and both of these performance measures were significantly different from those in the uncoated condition. In addition, mean response time was significantly faster in the bare-eye compared to the coated condition, although there was no effect of accuracy between these two conditions. For uncoated versus coated eyewear an increase in accuracy with the coated eyewear approached significance.

Résumé

Dans le but d'évaluer l'effet de la formation de buée sur des lentilles de lunettes sur la qualité d'exécution de tâches et l'efficacité des traitements antibuée, neuf participants ont exécuté une tâche de recherche visuelle dans des conditions simulant les deux principales situations propices à l'embuage de lunettes. Dans l'environnement statique, les participants ont dû effectuer une recherche visuelle assis à un terminal d'ordinateur. Les lunettes ont d'abord été imprégnées de froid dans un congélateur et puis remises aux participants pour simuler le passage d'un milieu extérieur froid à un milieu intérieur chauffé. Dans l'environnement dynamique, on a simulé la pratique d'activité physique dans le froid. Les participants devaient effectuer la tâche dans une chambre climatique refroidie tout en pédalant sur une bicyclette d'exercice. Dans cet environnement, les lunettes n'ont pas été imprégnées de froid au préalable mais remises aux participants avant qu'ils ne pénètrent dans la pièce. Les participants ont exécuté la tâche de recherche visuelle dans les environnements statique et dynamique dans trois états différents : sans porter de lunettes (œil nu), avec des lunettes traitées contre la buée (lunettes avec traitement anti-buée) et avec des lunettes non traitées contre la buée (lunettes non traitées).

Pendant l'exécution de la tâche, des enregistrements vidéos ont été faits pour chaque état et les participants ont fait part, à intervalle régulier, de leur évaluation subjective du degré d'embuage. La précision et la vitesse d'exécution de la tâche de recherche visuelle ont été consignées en tant que mesures de la qualité d'exécution.

Dans l'environnement statique, l'embuage s'est produit sur la lunette non traitée dès son retrait du congélateur et a persisté pendant les deux premières minutes de la recherche visuelle. La lunette traitée s'est également embuée dans le cas de six des neuf participants mais pour une période beaucoup plus courte. Les participants exécutaient leur tâche avec beaucoup plus de précision lorsqu'ils ne portaient pas de lunettes ou qu'ils portaient des lunettes traitées comparativement à leur performance avec des lunettes non traitées. On n'a enregistré aucun effet notable de la buée sur le temps de réaction, mais des réactions plus lentes ont été observées chez les participants qui ne portaient pas de lunettes. Il est probable que le manque d'habitude à exécuter la tâche en question ait contribué à ce résultat.

Dans l'environnement dynamique, la buée a, en moyenne, commencé à se former sur les lentilles à la huitième minute d'exercice. Sur les lunettes non traitées, la buée s'est déposée en une couche très visible, alors que sur les lunettes traitées, il s'est plutôt formé une fine pellicule d'humidité. La précision d'exécution moyenne de la tâche était plus élevée et le temps de réaction moyen était plus rapide dans la condition d'œil nu et ces deux mesures de la qualité d'exécution ont été très différentes de celles enregistrées avec les lunettes non traitées. De plus, le temps de réaction moyen était de beaucoup plus rapide dans le cas de l'œil nu plutôt que dans celui des lunettes traitées, bien que le degré de précision n'ait pas été touché pour ces deux conditions. En ce qui concerne les lunettes non traitées par rapport aux lunettes traitées, on a remarqué une nette amélioration de la précision.

Executive summary

In environmental conditions where there is rapid change in temperature and humidity, moisture has a tendency to condense on the lens surface of eyewear, seriously impeding the vision of the wearer. This condition commonly occurs when moving from a cold exterior environment into a heated interior, or when exercising in the cold. The aim of this study was: a) to determine the effect of eyewear fogging on visual task performance; b) to assess the effectiveness of an anti-fog coating; and c) to determine whether a bench test for fogging could be related to operational fogging conditions.

Nine participants completed a visual search task under two simulated fogging environments. In the static environment participants performed the task while seated in front of a computer terminal and the eyewear was cold soaked in a cooler prior to being donned to simulate moving from a cold exterior to a warm interior environment. In the exercise environment, to simulate exercising in the cold, participants performed the visual search task in a cooled climatic chamber while peddling a cycle ergometer. In this environment the eyewear was not cold soaked but was donned prior to entering the chamber. All participants performed the visual search task in both environments (static and exercise) under three conditions: a) wearing no eyewear (bare-eye); b) wearing eyewear that had been coated with an anti-fog coating (coated eyewear); and c) wearing eyewear that had not been treated with anti-fog coating (uncoated eyewear).

Each condition was video recorded and participants' subjective evaluations of the degree of fogging were collected at regular intervals throughout the task. Accuracy and speed of response on the visual search task were collected as performance measures. The results of this study showed that: a) fogging of the eyewear lens has a significant detrimental effect on task performance; b) anti-fog coatings are relatively effective; but c) in environments where prolonged fogging is likely, water forms a thick layer on anti-fog coated lenses, which disrupts visual performance in a manner similar to the fogging it is trying to prevent. It is recommended that:

1. Anti-fog coatings be considered in any future Canadian Forces (CF) purchase of ballistic protective eyewear;

2. Eyewear purchased be evaluated using the methods developed for the static portion of this experiment;

3. Future oculofacial protection devices (visors) be evaluated for visual obstruction due to fogging in a similar manner before procurement;

4. A bench test method should be developed based on these results to verify the quality of coatings applied in future procurements.

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Sommaire

Dans des conditions environnementales où se produisent de rapides variations de température et d'humidité, l'humidité a tendance à se condenser sur la surface des lentilles de lunettes, nuisant ainsi sérieusement à la vision de l'utilisateur. Cette condition se produit fréquemment lorsque la personne passe d'un milieu extérieur froid à un milieu intérieur chauffé, ou lorsqu'elle pratique une activité physique dans le froid. La présente étude visait à : a) déterminer l'effet de lentilles de lunettes embuées sur la qualité d'exécution d'une tâche visuelle; b) évaluer l'efficacité d'un traitement anti-buée; et c) déterminer si un essai en laboratoire sur l'embuage pourrait être associé aux conditions de fonctionnement propices à l'embuage.

Neuf participants ont exécuté une tâche de recherche visuelle dans deux environnements simulant des conditions propices à la formation de buée. Dans l'environnement statique, les participants ont exécuté la tâche tout en étant assis à un terminal d'ordinateur et les lunettes ont été imprégnées de froid dans un congélateur avant qu'on les leur remette pour simuler le passage d'un milieu extérieur froid à un milieu intérieur chauffé. Dans l'environnement dynamique, il s'agissait de simuler la pratique d'une activité physique dans le froid. Les participants ont donc exécuté leur tâche de recherche visuelle dans une chambre climatique refroidie tout en pédalant sur une bicyclette d'exercice. Dans cet environnement, les lunettes n'ont pas été imprégnées de froid mais elles ont été remises au participant avant qu'il ne pénètre dans la chambre. Tous les participants ont effectué la tâche de recherche visuelle dans les deux environnements (statique et dynamique) dans trois états différents : a) sans porter de lunettes (œil nu); b) en portant des lunettes traitées contre la buée (lunettes traitées); et c) en portant des lunettes non traitées contre la buée (lunettes non traitées).

Chaque condition a été enregistrée sur bande vidéo et, pendant l'exécution de la tâche, les participants ont fait part à intervalle régulier de leur évaluation subjective du degré d'embuage. La précision et la vitesse de réaction pendant l'exécution de la tâche de recherche visuelle ont été consignées en tant que mesures de la qualité d'exécution. Les résultats de l'étude ont montré que : a) la formation de buée sur les lentilles de lunettes a une incidence très négative sur la qualité d'exécution d'une tâche; b) les traitements antibuée sont relativement efficaces; c) dans des environnements où il y a une probabilité d'embuage prolongé, l'eau forme une pellicule épaisse sur les lentilles traitées contre la buée, ce qui nuit à l'acuité visuelle autant que la buée que le traitement vise à éliminer. En conséquence, on recommande : d'opter pour des lunettes traitées contre la buée dans tout achat futur de lunettes de protection balistique par les Forces canadiennes (FC);

1. d'évaluer les lunettes achetées à l'aide des méthodes élaborées dans la partie statique de la présente expérience;
2. d'évaluer, suivant la même méthode, le degré d'embuage des futurs dispositifs de protection oculofaciaux (visières) avant de les acheter;
3. d'élaborer, d'après ces résultats, une méthode d'essai en laboratoire visant à vérifier la qualité des traitements antibuée appliqués en vue d'achats futurs.
4. d'élaborer, d'après ces résultats, une méthode d'essai en laboratoire visant à vérifier la qualité des traitements antibuée appliqués en vue d'achats futurs.

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Introduction

Background

In a military setting, just as in any workplace, the eye is exposed to a myriad of potential hazards. In the combat environment the eye is particularly vulnerable to injury from fragmentation and flying debris, as well as accidental injury incurred through the handling of munitions and equipment. The incidence of ocular trauma during wars, such as World War I and II, the Korean War, the Arab/Israeli War, and the war in Vietnam, has been reported in the range of 2 to 6% (1).

The type of protective eyewear issued to soldiers in the past has often been cumbersome and provided inadequate protection. Only twenty-seven percent of soldiers who suffered ocular injury while on duty in the West Bank and Gaza were issued protective fibreglass faceguards and none, at the time of injury, were wearing the faceguards (2). Soldiers report that such equipment is awkward, scratches easily, and limits their ability to use binoculars and aiming devices. Hence, even if some form of eye protection is available to soldiers there is no assurance that it will be worn at the appropriate time to help prevent injury. Consequently, the importance of ballistic protective lenses that do not impede the soldier's activities in a combat environment cannot be overemphasized.

The Canadian Land Forces recognizes this need and has committed to provide ballistic protective eyewear to the Land Force under the Clothe the Soldier Project. The Statement of Requirements for this item states that eyewear must provide protection from ballistic, solar and laser threats under all operational and environmental conditions (3). In environmental conditions where there are rapid changes in temperature and humidity, moisture has a tendency to condense on the lens surface of eyewear, seriously impeding the vision of the wearer. This fogging, or misting effect, can occur when moving from a cold exterior environment into a heated interior, or when exercising in a cold environment. The soldier is exposed to these circumstances regularly when fighting in built up areas (FIBUA), where ballistic protective eyewear is most critical due to the high fragmentation threat. In a comprehensive study of goggles it was determined that the most common reason for removing protective goggles was lens fogging (4).

This study attempts to quantify the effect fogging has on FIBUA operations by simulating appropriate environmental conditions that induce fogging while having individuals perform a visual task in a controlled laboratory setting. It was recognized early on in the evaluation of ballistic eyewear for Canadian Forces use that the bench tests for fogging used by the Canadian Standards Agency (5) and the Comité Européen Normalisation (6) did not reflect the fogging conditions that were most relevant to the soldier. Current fogging evaluation techniques all rely on cooling the eyewear to a certain temperature and then exposing it to higher temperature and humidity levels (7). While these techniques are repeatable they may not realistically reflect common fogging environments. Consequently this study attempts to simulate fogging environments commonly encountered by the field soldier, plus show a link between these conditions and a simple human based test for fogging that would then lead to a

reliable, repeatable bench test. Temperatures below 0° Celsius were not examined in this study as, at these temperatures, moisture freezes on the lens surface. The temperature range of 0-15 °C was selected to be used as representative of fogging conditions experienced on field trials of ballistic eyewear and the ballistic visor (8,9).

Aim

The aim of this study was to: a) determine the effect of eyewear fogging on visual task performance; b) assess the effectiveness of an anti-fog coating; and c) to determine whether a bench test for fogging could be related to operational fogging conditions.

Fogging - Definitions

For the purpose of this study fog is defined as a moisture layer on an optical surface producing a clouded appearance due to the scattering of light. The accumulation of moisture is caused by condensation. Condensation is the deposit of water vapour from the air on any cold surface whose temperature is below the dew point. Resistance of a lens to fogging is a function of the lens material and fit of the device with respect to the face, airflow, temperature and humidity (10).

Method

Apparatus for the static environment

Presentation of visual search task

The visual search task was presented on a Macintosh computer with a 20-inch (51cm) colour monitor which was placed approximately one meter in front of the participant on a level plane (Figure 1). The participant could adjust the keyboard position for comfort. Thirty-six grey circles were presented on the screen in the cells of an imaginary 6 x 6 grid with small positional offsets (+/- 3 pixels) selected at random for each item (Figure 2). Each circle subtended 1.2° visual angle and the entire array subtended approximately 18° x 18° on the screen. On half the trials one of the circles (target) appeared lighter than the others (distractors). The task consisted of searching for a target among distractors. Luminance of the target symbol was 18.0 cd/m^2 (chromaticity co-ordinates: x = .275, y = .309), whereas luminance of the distractors was 14.0 cd/m^2 (chromaticity co-ordinates: x = .276, y = .307). Display background luminance was maintained at 32.0 cd/m^2 (chromaticity co-ordinates: x = .275, y = .298).

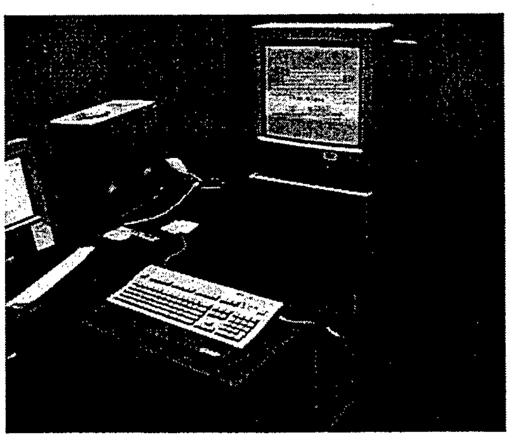


Figure 1

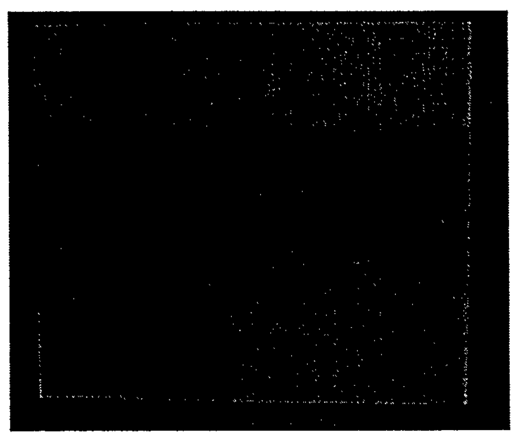


Figure 2

Figure 1. *Equipment set-up, static environment*

Figure 2. *Visual task stimuli*

Eyewear

Bolle Edge I or Edge II eyewear were worn in this experiment. Edge I shield dimensions were 17 cm by 5.5 cm, while Edge II shield dimensions were 15.5 cm by 5 cm (Figure 3) to fit narrower faces. The two sizes were necessary to fit all participants adequately (Annex A). Both sizes of eyewear featured a 2 mm thick clear polycarbonate lens that had an anti-scratch coating applied. In addition, for the coated condition, a factory applied anti-fog coating was purchased for the same eyewear. The eyewear represents a shield-type eyewear system that does not interfere with the CG 634 helmet straps and that was readily available for purchase with and without anti-fog coating. By testing a single eyewear brand it was possible to control the variables of fit, lens material and airflow to a greater degree. Participants were asked to adjust the temple arms to give a close, comfortable fit and then retain the same adjustment for all subsequent conditions.

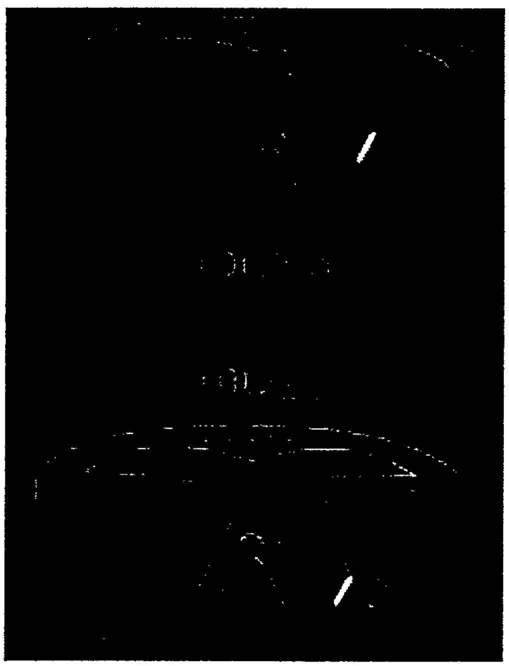


Figure 3

Figure 4

Figure 3. *Shield type eyewear*

Figure 4. *Helmet CG-634*

Helmet and clothing

Participants wore the Canadian Forces issue CG634 Soldiers Helmet (Figure 4), and running shoes, fleece pants, and jacket over a T-shirt. The helmet was fitted using the procedures specified in Annex A.

Digital video camera

A Canon XL1 3CCD NTSC Digital Video Camcorder was used throughout the experiment to record a close-up of the eyewear and extent of fogging and to record the actual timings of the fogging event. The camera was positioned slightly above and behind the monitor.

Environmental conditions

The room selected for the static environment was a standard office with normal temperature humidity and lighting conditions. Illuminance of the room was 145 lux measured using a Hagner Universal Photometer. Room temperature and relative humidity were monitored over a two-week period with a mean temperature (T) of 22.1°C (SD ±1.53°) and a relative humidity (RH) of 51.3% (SD ± 7.1%). A Coleman electric cooler was used to provide a cool microclimate to condition the eyewear. The temperature of the cooler was maintained at 0° C.

Using Margrain's technique to calculate dewpoint, temperature of 10° C and 50% RH should yield a dewpoint of 21° C, and for 0° C and 50% RH a dewpoint of 10°C (7). Pilot testing indicated that these temperature ranges would allow fogging of the eyewear to commence within a reasonable time period. Actual temperature and humidity data are included in Annex B.

Apparatus for the exercise environment

Presentation of visual search task

The visual search task and stimuli were the same as in the static environment except that participants were seated on a cycle ergometer to perform the task (Figure 5).

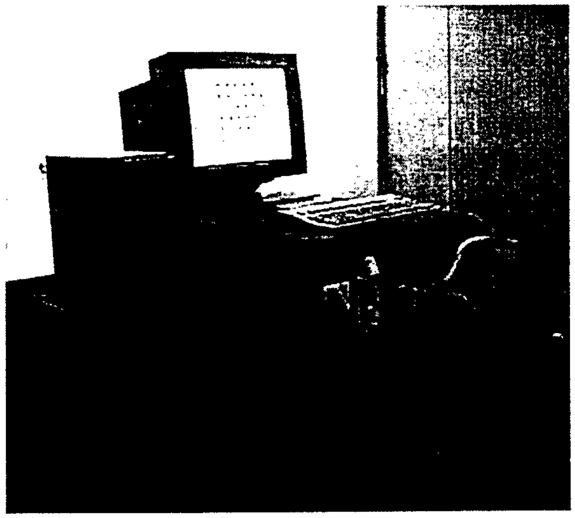


Figure 5. Equipment set-up, exercise environment

Cycle Ergometer

A cycle ergometer was used to create simulated operational workload. Participants were allowed to adjust seat and handlebar heights and to set the level of tension for individual preference. Workload was determined by estimating maximum heart rate that was calculated by subtracting participant's age from 220 and selecting a 60-70% range of this value. Heart rate was monitored at all times by a wrist worn heart rate monitor.

Eyewear

Eyewear was the same as for the static environment.

Helmet and Clothing

Participants wore the Canadian Forces issue CG634 Soldiers Helmet. The helmet was fitted using the procedures specified in Annex A. Pilot testing had revealed that a large amount of airflow in the room from the refrigeration unit, and around the face from head movement and body motion on the ergometer was limiting the production of fog on the lenses. To restrict airflow the helmet was adapted by adding a face shield across the mouth area (Figure 6). As in the static condition, participants also wore fleece pants and jacket over a T-shirt and running shoes.

Figure 6. Helmet with faceshield

Digital video camera

Same as for static environment.

Environmental conditions

A small environmental chamber (approx. 3 metres x 3 metres) capable of maintaining a constant temperature and relative humidity was selected for the exercise condition. Illuminance of the chamber was 107 lux taken using a Hagner Universal Photometer. Chamber temperatures and relative humidity (RH) were monitored over the course of the experiment with a mean temperature of 12.6°C (SD ± 1.95°) and a mean RH of 45.9% (SD ± 10.31%).

Participants

Nine participants, one female and eight males, between the ages of 25 and 44, participated in this study. Participants were medically screened for general health and fitness. All

participants had 6/6 uncorrected vision. Colour vision was measured using Ishihara plates and all participants were free from visual defects.

Anthropometry

Anthropometric measurements were gathered from all participants, including head circumference and head breadth to ensure proper helmet sizing, and bizygomatic breadth and interpupillary distance to ensure proper eyewear sizing (Annex C).

Procedure for static and exercise environments

Each subject participated in three experimental sessions each conducted on three separate occasions. The first session was the bare-eye condition in which the subject could become familiar with the task without eyewear. The second and third sessions were conducted while wearing either the coated eyewear (i.e., eyewear treated with anti-fog coating), or uncoated eyewear (i.e., eyewear not treated with anti-fog coating).

All sessions consisted of testing in the static environment followed by testing in the exercise environment, employing the same eyewear condition in each session. The static test always preceded the exercise test to eliminate the confounding factor of increased body temperature during testing in the static environment.

Participants were first fitted with a helmet and checked to ensure compliance with the clothing specified. They were then taken to the static test station and seated in a chair approximately 1 metre from the computer monitor. Head height and comfort adjustments were made in the seated position. The video camera was aligned so that it was focused on the eyes and upper face and the participant was instructed to restrain head movement during the experimental session as much as possible. A brief task familiarization was conducted to introduce the task, and participants were briefed according to the information in the participant instructions (Annex D). If the particular session required eyewear, it was conditioned at 0° C in a small cooler for a minimum of one hour prior the start of the experimental session.

The experimental trials began after completion of eight practice trials. In the sessions where eyewear was required, immediately following the practice trials the participants were handed a set of eyewear obtained from the cooler and instructed to don them and begin the task. Care was taken not to touch the lenses during the exchange or while the eyewear was being adjusted.

The session consisted of 600 trials with no breaks, which took approximately 25 minutes to complete, and the task was to judge whether a target symbol was present among the distractors. Responses were made by pressing the '1' key on the numerical pad of the keyboard if the target was absent, and the '2' key if the target was present. Participants were instructed to respond as accurately and as quickly as possible and to make their best guess if fogging impaired their vision so completely that they were unable to distinguish target from distracter. Feedback was provided after each trial with a '+' or a '-' on the screen, signifying a correct or incorrect response respectively. The secondary function of this feedback was to ensure that participants kept their eyes focused on the centre of the screen at the beginning of

every trial thereby minimizing head movement so that the appropriate area on the face was recorded by the digital camera.

At the end of the static session participants were asked to remove the eyewear and were accompanied to the climatic chamber to complete the exercise session. Participants were allowed to enter the chamber briefly and adjust the ergometer seating for height and comfort. They were then taken to an anteroom and fitted with a heart rate monitor and a modified helmet. If eyewear was required it was kept at room temperature and donned upon re-entry into the chamber. The individual began cycling as soon as the computer task was started. At completion of the task, participants were asked to stay seated on the ergometer to monitor fogging dissipation.

Subjective measurement technique

A five-point scale was presented to participants verbally at specific intervals throughout the experiment. In the static environment participants were asked for their evaluation of the degree of fogging on the lenses at the following times: immediately after donning the eyewear, 30 seconds into the task, every minute thereafter for the first five minutes, then once every five minutes until they finished the task. For the exercise environment participants were asked once every five minutes until fogging began, then once a minute until the session was complete. The scale was rated 1 – 5: 1 indicating no fogging visible, and 5 being vision completely obscured (Figure 7).

1 No fogging	2	3	4	5 Completely Obscured

Figure 7. *Subjective scale presented to participants*

Results

Subjective results

Static condition

Examination of the videotape footage indicated that fogging occurred on the uncoated eyewear almost immediately after the eyewear was donned. The subjective ratings of fogging in the coated and uncoated static conditions are shown below (Figures 8a, 8b). In all cases the uncoated eyewear fogged extensively and took up to two minutes to clear to the point where participants rated performance on the task as unaffected. In the coated eyewear condition (Figure 8b) six of the nine participants reported brief fogging which dissipated within one minute. A two-tailed t- test of the static subjective scores showed that the coated eyewear required significantly less time to clear ($p = .029$, where $p < 0.05$ indicates significance).

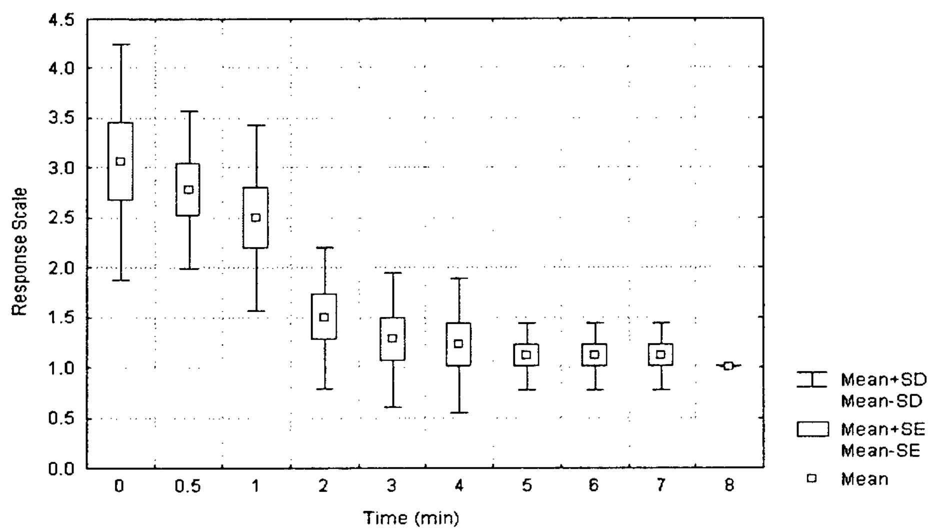


__Figure 8a.__ Mean subjective responses to fogging on uncoated eyewear in the static environment

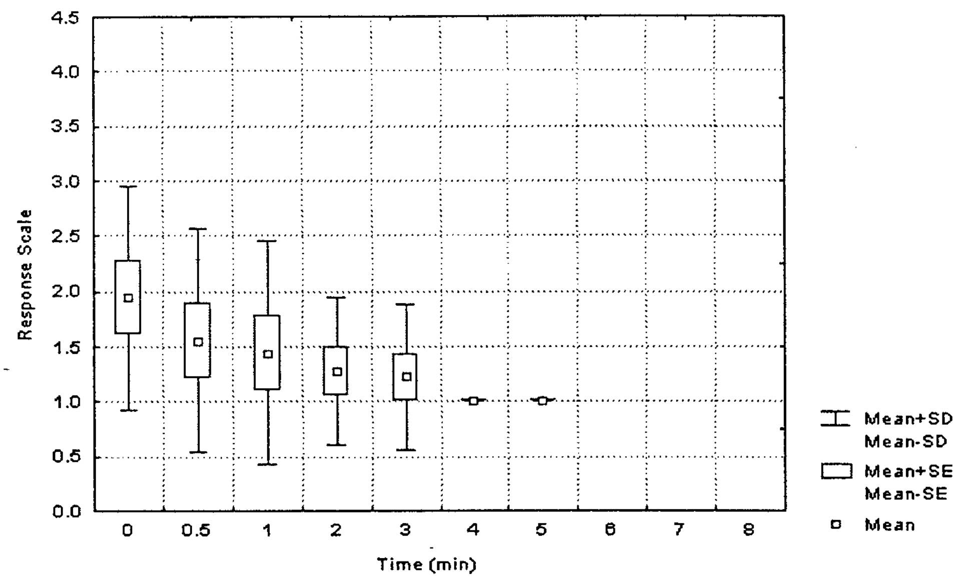


Figure 8b. *Mean subjective responses to fogging on the coated eyewear in the static environment*

Exercise condition

The subjective ratings of fogging in the coated and uncoated exercise conditions are shown in Figures 9a and 9b. Fogging was reported on the uncoated eyewear at a mean time of six minutes after the task began. Dissipation of the fogging on uncoated eyewear (Figure 9a) was not reported until, on average, five minutes after the task was completed and the eyewear was removed. In the coated condition fogging, as defined in this paper, occurred only briefly. Instead, a film of water built up on the inside of the lenses in 6 of the 9 participants. This effect began at approximately the same time as fogging on the uncoated eyewear and remained until the end of the session. The effect of this film was sufficient to raise the mean subjective scores to 2.7 at approximately the eighteen-minute mark (Figure 9b). A two-tailed t-test of the subjective scores failed to show any effect of time to clear as a function of the type of eyewear worn.

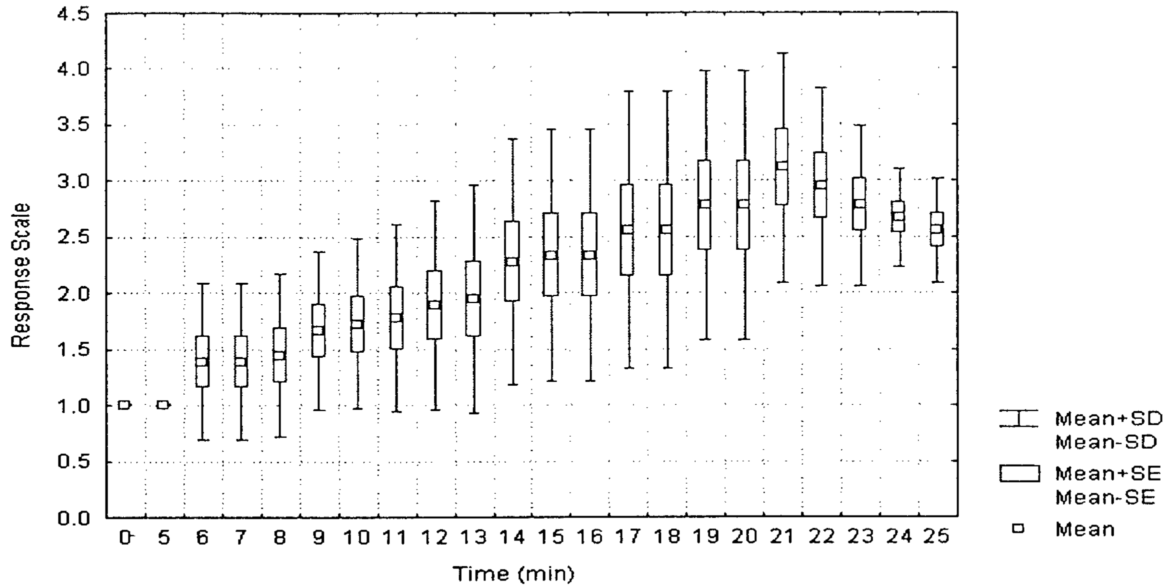


Figure 9a. *Mean subjective responses to fogging on the* <u>*uncoated*</u> *eyewear in the exercise condition*

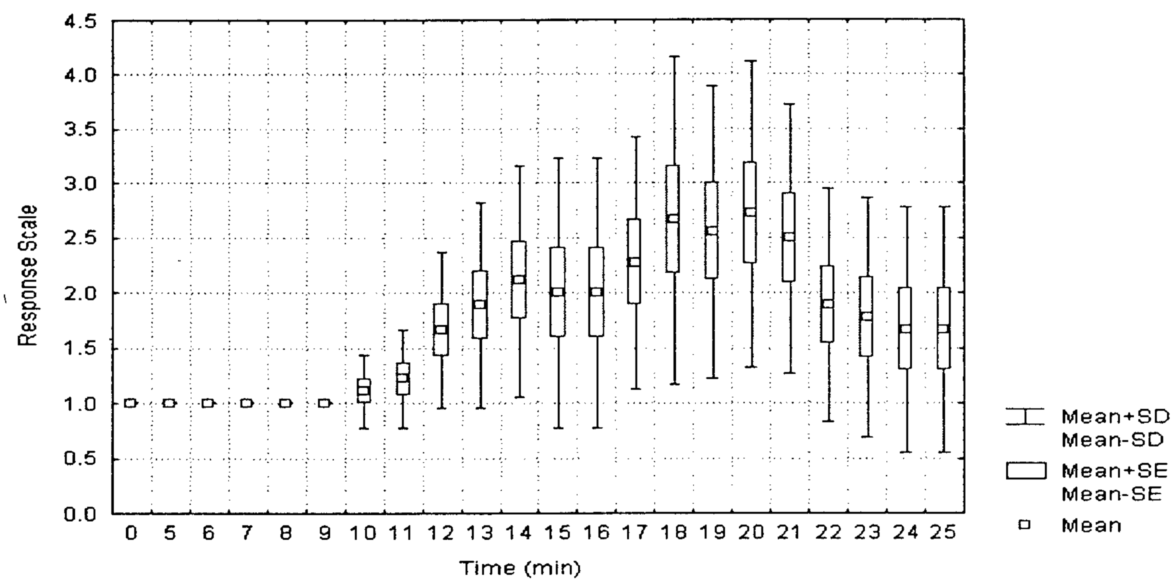


Figure 9b. *Mean subjective responses to fogging on the* <u>*coated*</u> *eyewear in the exercise condition*

__Figure 10a.__ Uncoated eyewear at the start of the exercise environment

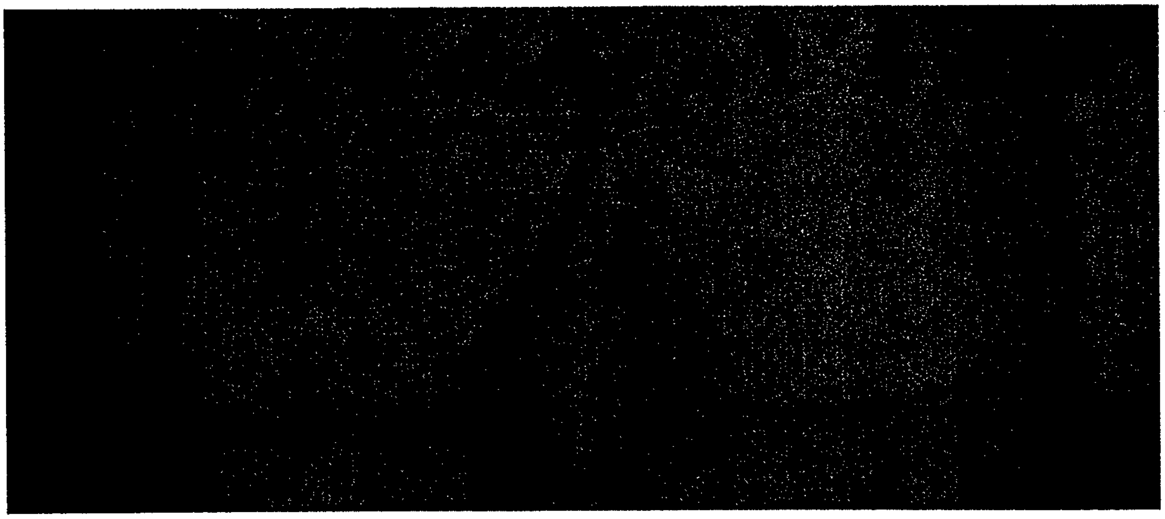


__Figure 10b.__ Uncoated eyewear after 20 minutes of the exercise environment

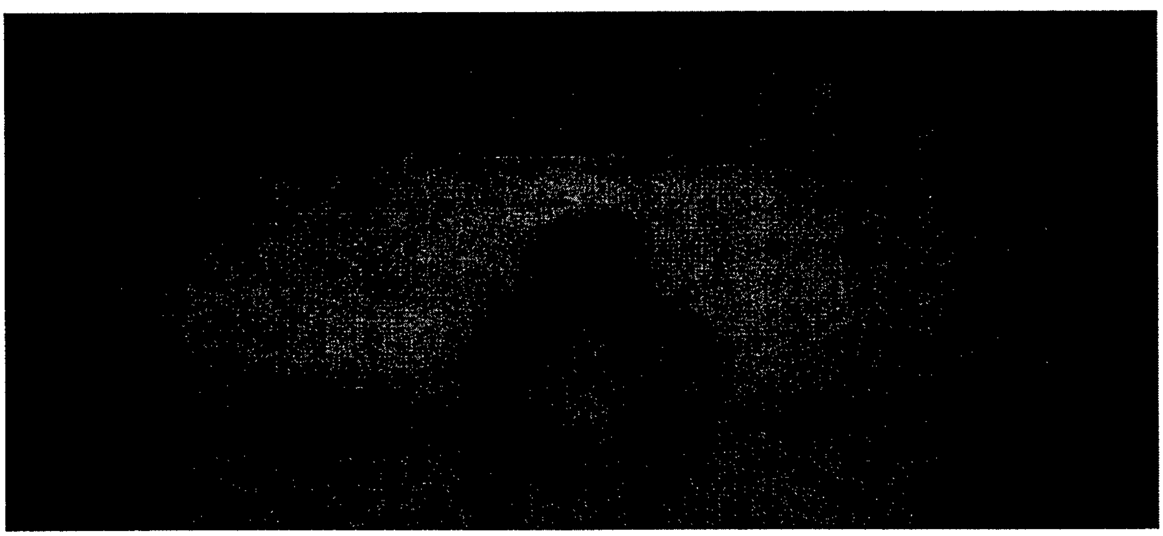


Figure 10c. Uncoated eyewear at the end of the exercise environment

Task performance

Static environment

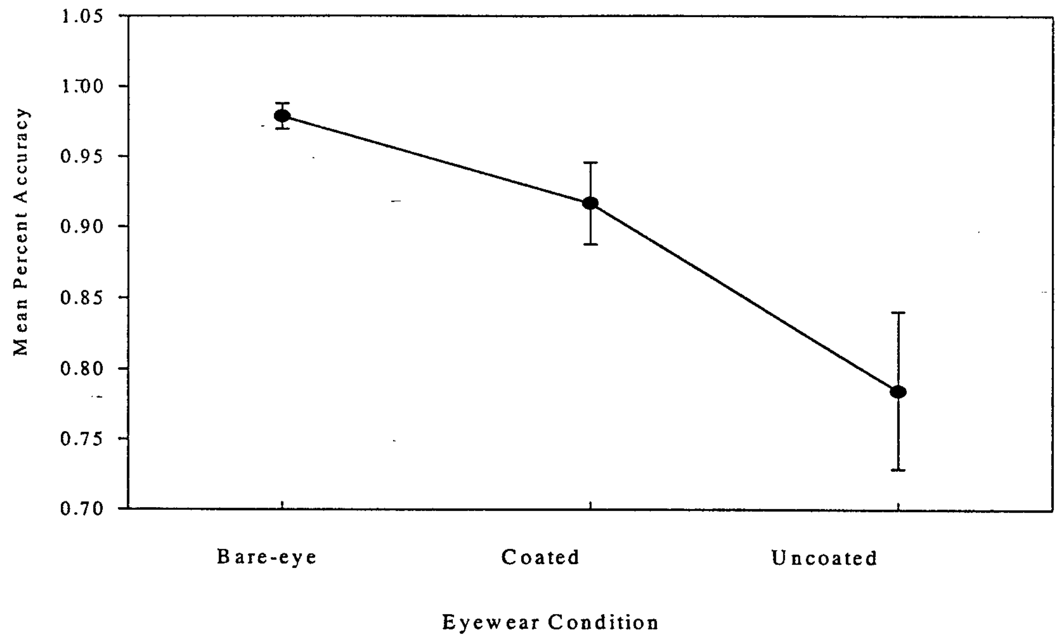
Data time frames

The videotapes showed that the degree and duration of fogging in the static environment correlated with the subjective evaluations. For most participants fogging occurred in both the coated and uncoated conditions. To analyze the data, for each participant the shortest time period where fogging was present was selected and mapped to the other condition and to the bare-eye condition so that an equal number of trials could be compared. Limiting the time periods in this fashion resulted in an average of 1.5 minutes of data for each participant for each condition in the static environment (see Annex D for each participant's time frame).

Accuracy

Cell means for each participant in each condition (bare-eye, coated, uncoated) were entered into a repeated measures analysis of variance (ANOVA) with condition as a within-subjects factor. An effect of condition was evident [$F_{(2,16)} = 11.18, p < .001, MS_e = .008$], with highest accuracy observed for the bare-eye condition (M = .979), lowest for the uncoated condition (M = .785), and the coated condition (M = .917) intermediate between the two (see Figure 11). Scheffé post hoc comparisons revealed that accuracy in the uncoated condition was significantly lower than either the coated ($p < .0214$) or bare-

eye conditions ($p < .0012$). There was no significant difference in



performance between the bare-eye and coated conditions ($p > .354$).

***Figure 11.** Mean accuracy on the visual search task in the static condition*

It seemed appropriate at this time to examine whether or not any effect of wearing eyewear was present, independent of fogging. Cell means for those trials in which fogging did not occur (i.e., trials that occurred after the ~1.5 minute mark) for each participant in each condition (bare-eye, coated, uncoated) were entered into a repeated measures ANOVA with condition as a within-subjects factor. No effect of condition was present [$F_{(2,16)} = 2.689$, $p > .098$, $MS_e = 1.046E\text{-}4$]. In addition, looking at the condition in which most fogging occurred (i.e., the uncoated eyewear condition), accuracy on the task when fogging had dissipated rose to 97.5%, from 82% when fogging was present ($p > .0037$). These results clearly show that, in the absence of fogging, wearing eyewear did not interfere with an individual's ability to perform the task.

Response time

Only trials during which the target was correctly identified as present or absent were used in response time analyses. No effect of response time was evident when cell means for each participant in each condition (bare-eye,

coated, uncoated) were entered into a repeated measures ANOVA with condition as a within-subjects factor [$F_{(2,16)} = 1.06, p > .369, MS_e = 3592783$]. As seen in Figure 12, the analysis revealed that response time in the coated eyewear condition (M = 1977 ms) was shorter than in the uncoated condition (M = 2962 ms) and that slowest performance overall was observed for the bare-eye condition (M = 3206 ms).

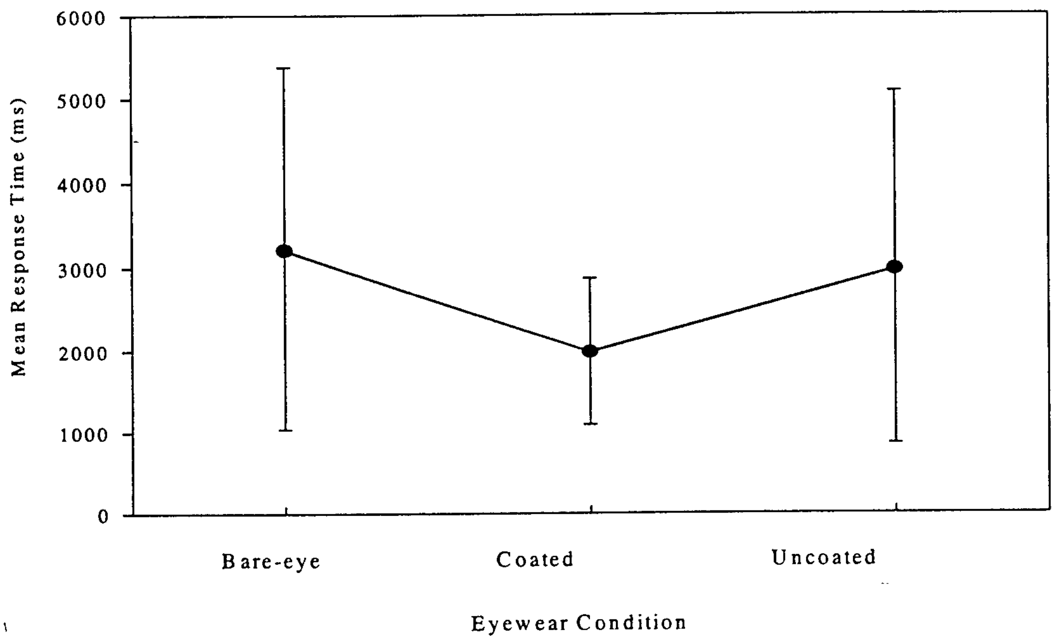


Figure 12. *Mean response time (ms) on the visual search task in the static environment*

The finding that slowest response times were associated with the bare-eye condition came as somewhat of a surprise. However, on reflection, it seems fitting that the response times for this particular session might be slowest overall as all participants performed in the bare-eye static condition first, prior to any other session, and may have been unfamiliar with the search task at this point, resulting in longer response times.

Possibly associated with this proposal is the observation that response times in the exercise condition were considerably shorter (M = 1066 ms, see 3.2.2.2) than in the static condition (M = 2715 ms). One might expect such a pattern if speed of response increased as each session progressed and participants became more familiar with the task. In the static environment performance was assessed based entirely on early trials in each condition

(trials within a window of ~1.5 minutes from the beginning of the session), whereas in the exercise environment performance was based on later trials (trials within a window of ~14.5 minutes from the end of each session). Thus, it is feasible that participants would be more practiced and respond faster on those trials included in the exercise condition analyses in contrast to the static condition.

To examine this possibility in the static environment a comparison was made of early and later sections of the experiment. Early trials in the bare-eye condition (from the beginning of the session, to ~1.5 minutes into the experiment) were compared to later trials in the coated and uncoated conditions (> ~1.5 minutes into the session, to the end). Theoretically, under these circumstances, where fogging of the eyewear was not a factor, there should be no difference in performance between any of the conditions. Findings from this analysis however support a contributing effect of practice by showing that mean response time in the early part of the experiment was significantly slower (bare-eye M = 3206 ms) than in later sections of the experiment (coated M = 995 ms; uncoated M = 1399 ms) [$F_{(2,16)} = 8.89$, $p < .0026$, $MS_e = 1402617$].

Discussion

In the static environment, fogging occurred on the eyewear immediately after it was removed from the cooler and continued for approximately 1.5 minutes into the experimental trials. Both the video recording taken during the experimental session, and the subjective ratings of the participants, support this observation.

A summary of the statistical probability values for accuracy and response times for each eyewear condition used in the static environment is shown in Table 1.

TABLE 1. *Summary of probability of difference between eyewear conditions in accuracy and response time (RT) in the static condition (* significant)*

Bare-eye/Coated		Coated/Uncoated		Bare-eye/Uncoated	
Accuracy	RT	Accuracy	RT	Accuracy	RT
.354	.408	.021*	.557	.001*	.963

Effects of fogging were observed for accuracy but not for response time. Although fogging often occurred on coated eyewear, accuracy was

significantly lower only when the eyewear was uncoated. There was no difference in performance, either in accuracy or response times, between the coated eyewear and the bare-eye conditions. Consequently, the application of anti-fog coating to the eyewear was advantageous in increasing participants' ability to perform the visual task when fogging was produced in a static environment in this study.

Although no significant effects of fogging were observed for response times the observation that mean response time was slowest for the condition in which no eyewear was worn was noted. As already discussed one reason for this may have been lack of familiarity with the task during this session. As there were very few trials used in the analysis of performance in the static environment, and these trials were at the beginning of the study, it is possible that participants were slow to respond simply because of insufficient practice in performing the task. Accuracy, however, was not affected, suggesting that individuals were focused on correctly detecting the target, even though the task in this session took them longer to perform than in subsequent conditions.

Exercise environment

Data time frames

In the exercise environment, two types of moisture build-up occurred, fogging as defined in this study, and a film of water. Fogging occurred on the uncoated eyewear for all participants, while the water film occurred in the coated condition for six of the nine participants. As in the static environment, the shortest time period in which fogging of the eyewear occurred was determined for each participant and mapped to each of the other conditions. The time period was calculated as being 2 minutes prior to the onset of fogging or water film until the end of the experimental session. This procedure resulted in an average of 14.5 minutes of experimental trials per participant, per condition (see Annex E).

Accuracy

Cell means for each participant and each condition (bare-eye, coated, uncoated) were entered into a repeated measures ANOVA with condition as a within-subjects factor. As shown in Figure 13, a significant effect of condition was present [$F_{(2,16)} = 5.6, p < .0144, MS_e = .003$] in that accuracy was highest for the bare-eye condition (M = .971), intermediate for the coated condition (M = .953), and lowest for the uncoated condition (M = .889). Scheffé post hoc comparisons revealed that accuracy in the bare-eye condition was significantly higher than in the uncoated condition (p < .021), and this difference approached significance for the coated and uncoated

comparison ($p < .072$). Performance in the bare-eye and coated conditions was not statistically different ($p > .798$).

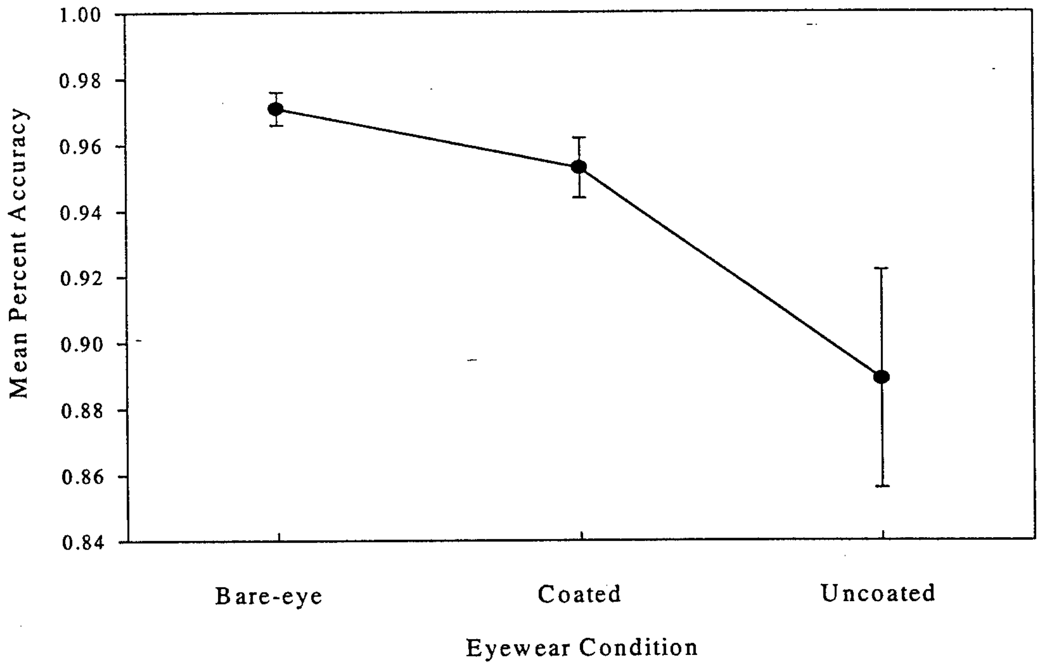


***Figure 13.** Mean accuracy on the visual search task in the exercise environment*

Response time

As in the static environment response times for trials on which the response was correct were entered into a repeated measures ANOVA with condition (bare-eye, coated, uncoated) as a within-subjects factor. Figure 14 shows the effect of condition [$F_{(2,16)} = 8.66$, $p < .0029$, $MS_e = 31850$]. Shortest mean response time was observed in the bare-eye condition (M = 872 ms), followed by the coated condition (M = 1115 ms), while mean response time was longest for the uncoated condition (M = 1211 ms). In contrast to accuracy measures in which paired comparisons revealed a significant difference between performance in the coated and uncoated conditions, no such difference was found in the response time data (Scheffé $p > .53$). However, the bare-eye and coated conditions ($p < .035$), as well as the bare-eye and uncoated comparisons ($p < .0037$) were significantly different.

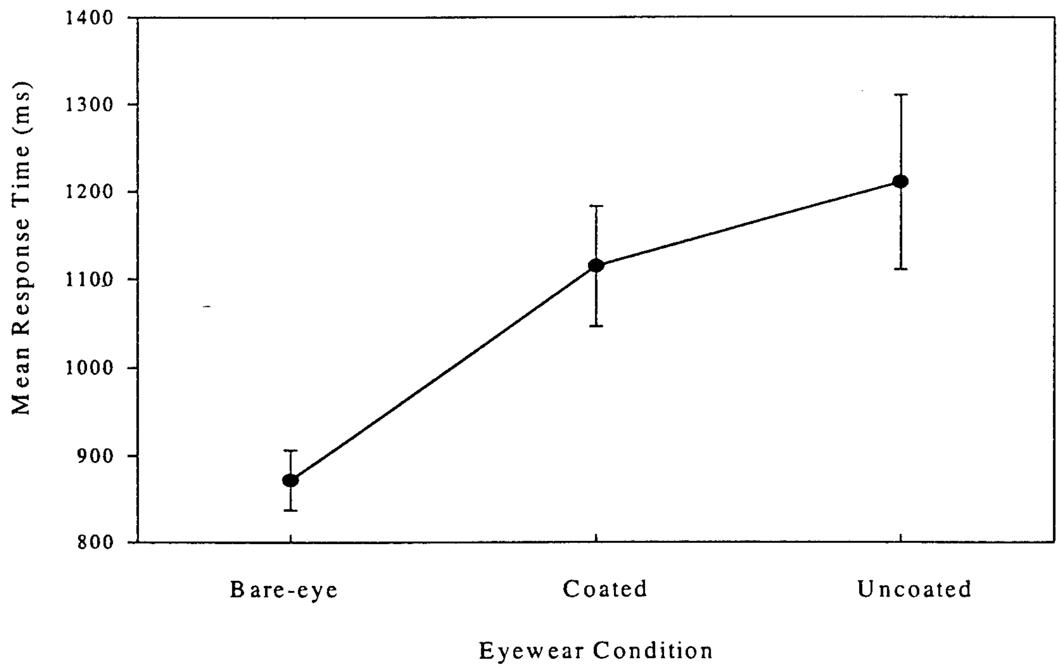


Figure 14. *Mean response time on the visual search task in the exercise environment*

As previously discussed, performance in the exercise condition was faster than in the static condition and this might be because different parts of the experiment were examined in these analyses. To investigate this issue in the exercise environment late trials in the bare-eye condition (> ~14.5 minutes before the end of the session) were compared to early trials (< ~14.5 mins) in the coated and uncoated conditions. As found in the static analysis, mean response time on the late trials (bare-eye M = 871 ms) was faster than the early trials (coated M = 1003 ms; uncoated M = 1043 ms) [$F_{(2,16)} = 7.941, p < .0041, MS_e = 9151$] suggesting an effect of practice as the experiment progressed.

Discussion

Table 2 shows a summary of the probability values for the three different eyewear conditions in the exercise environment sessions.

TABLE 2. *Summary of probability of difference between eyewear conditions in accuracy and response time (RT) in the exercise environment (* significant)*

Bare-eye/Coated		Coated/Uncoated		Bare-eye/Uncoated	
Accuracy	RT	Accuracy	RT	Accuracy	RT
.798	.034*	.071	.533	.02*	.003*

Performance was degraded when participants wore eyewear that had not been treated with anti-fog coating compared to performance while wearing no eyewear. The effects of fogging on the eyewear severely affected performance on the visual search task, both in accuracy and speed of response. Comparison of performance between the coated eyewear condition and the other two conditions, bare-eye and uncoated, was more variable. Within each condition, the accuracy and response time means followed similar patterns. But an effect of speed of response, not accuracy, was apparent between the bare-eye and coated conditions, whereas a difference in accuracy, but not speed of response, was evident, though not quite significant, for the coated eyewear condition compared to performance with uncoated eyewear. Therefore, in one comparison, response times were affected and in the other accuracy. These differences may reflect an interaction between the different types of moisture build-up on the coated and uncoated lenses during the exercise session. The water film occurred only on the eyewear that was treated with anti-fog coating, and the significant slowing in speed of response seen in this condition, compared to the bare-eye condition, may reflect visual interference caused by water on the lenses. Thus, participants took longer to find the target in the coated eyewear condition but were able to retain relatively high accuracy on the task. On the other hand, accuracy was affected in the uncoated condition in comparison to performance wearing the coated eyewear, reflecting an inability to correctly identify the target when the lenses were fogged. Overall, these findings suggest that, as fogging versus a water film formed, performance progressively declined. This is first reflected as a slowing in response time, followed by a drop in accuracy. This conclusion is supported by the significant degradation in performance, both in response time and accuracy, when uncoated eyewear was worn compared to performance while wearing no eyewear. Thus, in the exercise environment,

wearing eyewear of any kind impeded performance on the task, but wearing eyewear that was not treated with anti-fog coating resulted in a far greater decrement.

General discussion

The aim of this study was to quantify the effect of fogging on protective eyewear worn by the soldier, with the objective of evaluating anti-fog coating on eyewear. Fog formation occurs when the dew point is reached on the surface of the lens. In extreme temperature changes like those imposed by the Canadian Standards Association (CSA) technique (5), fogging occurs rapidly and severely, and is complicated by ice crystal formation. Anti-fog coatings cause a thin, transparent layer of water to form over the lens surface rather than individual droplets of water that disrupt light transmittance. This thin layer of water is then allowed to evaporate leaving a clear lens. At temperatures below 0° C this layer of water will freeze and obscure the vision (10). To eliminate this effect, and to simulate environments more applicable to the soldier, temperatures below 0° C were not selected in this experiment. In the temperature ranges chosen here, onset of fogging occurs in a readily observable timeframe and either dissipates quickly or intensifies depending on the environment.

The static condition in this study simulated fogging when moving from a cold to a warm environment. Fogging of the eyewear occurred for eyewear treated with anti-fog coating and eyewear that was not treated. In both cases, fogging appeared almost as soon as the eyewear was donned. However, the extent, severity and duration of fogging was considerably reduced on the coated eyewear. This observation was reflected in subjective evaluation of the degree of fogging, as well as in performance on the visual search task. Fogging of the lenses seriously affected the subjects' ability to correctly judge the presence of a visual target while wearing eyewear that had not been treated with anti-fog coating, although speed of response in judging the presence of the target was not affected in the same way. In fact, the pattern that emerged showed that responses were slowest when individuals wore no eyewear. This effect was likely due to participants being unfamiliar with the task while performing this initial session. Static and exercise sessions were run back to back and it was necessary to always conduct the static session before the exercise session. Performing in the exercise environment first would have resulted in an elevated body temperature in the following static session and it was important in the static environment that body temperature was normal. The bare-eye condition was a baseline condition and was always performed first. Thus, the static, bare-eye session was invariably the first session and the slower responses on the visual search task may have been a consequence of lack of familiarity with the task, as well as other factors that may have been unfamiliar to the participants, such as wearing a helmet. In support of the effect of familiarity with performing the task was the observation that speed of response tended to decrease as each session progressed. This was true for both static and exercise environments.

In the exercise condition fogging on the uncoated eyewear was induced by increasing body heat while exercising in a cold environment. Fog formed on the uncoated eyewear and impeded vision, as reported by the participants and as reflected in performance measures on the visual search task. Vision was also impeded for some participants when a thin layer of water built up on the eyewear that had been treated with the anti-fog coating. Fogging on the uncoated lenses and water film on the coated lenses appeared after about six minutes of cycling and remained until well after the visual task was completed, approximately twenty minutes.

Performance on the search task was affected by both these conditions but more so by fog on the uncoated eyewear than by the build-up of water on the coated lenses. Although the film of water on the coated eyewear slowed response times, there was a greater difference in overall performance on the visual task while wearing uncoated eyewear than there was while wearing coated eyewear, when compared to the bare-eye condition.

Although participants reported the degree of fogging on the uncoated eyewear to be similar in the static and exercise environments, fogging developed very differently under these two environmental conditions. We can therefore conclude that there are different characteristics to fogging of eyewear that appear to depend on the method by which fogging is produced. Moving from a cold to warm environment produces fogging of the lens quickly but the lens clears within a very short period of time. Fogging that occurs in a cold environment while the body generates heat, develops slowly but is prolonged. In addition, when moving from a cold to a warm environment, a short-lived, minimal degree of fog can occur on eyewear that has been treated with anti-fog coating. When condensation on the lens is produced by increasing body heat, a thin layer of water occurs rather than the traditional fogging which impedes vision. This state occurs when the low temperature and high humidity of the environment combine with the body heat of the individual to create a micro -environment behind the eyewear lens resulting in the saturation of the coating and a build-up of moisture.

Moreover, in contrast to the static environment, there was considerable individual variability in the amount of fogging, as well as the time of onset, on the uncoated lens in the exercise condition. This disparity is likely due to individual differences in the amount of body heat generated by each person while exercising and may be a reflection of individual fitness level. Typically, physical fitness is inversely related to the amount of heat and humidity produced by the body. Also, fewer variables in the static environment required control. For example, air movement was much more difficult to control in the exercise environment. The refrigeration unit of the chamber produced air movement, as did participants' head movement, which tended to increase with fatigue. Control of air movement proved to be one of the most challenging aspects of this study. A previous study of goggles found that airflow around the lens surface was the single most variable factor in the fogging event (11). Pilot testing concentrated on minimizing this effect and indicated that a confined space with minimal airflow was required for both the static and exercise environments. Airflow was further restricted around the lens surface by having the participants don a helmet prior to testing. In actual operations it is highly likely that helmet and eyewear would be worn together to combat the ballistic fragment threat. In the exercise environment airflow was restricted even further by use of a lower face shield to divert exhaled air. This type of device would not be present in actual field environments but other clothing items like collars and scarves could produce the same effect.

Task performance data clearly show a detrimental effect of having fogged lenses in front of the eyes while performing a visual task. They also show that the eyewear itself did not interfere with the individual's ability to perform the task. When fogging or water droplets did not impede vision, performance wearing eyewear equalled that of no eyewear. For example, when individuals wore uncoated eyewear in the static environment, task performance accuracy increased from 82% to 98% when fogged and clear conditions were compared. This indicates that while fogging had a significant effect for a very short duration, the task can be performed very well while wearing eyewear that is clear.

One of the aims of this study was to determine whether or not a suitable bench test could be developed to objectively assess the effectiveness of anti-fog coating on eyewear that might be requisitioned by the military in the future. Current Canadian (5) and European (6) standard testing specifications use extreme conditions (<= 0^0 Celsius), which results in rapid and severe fogging and the formation of ice crystals on the lenses. These conditions are not representative of the typical environment incurred by military personnel, and a bench test that reflects the appropriate environment and conditions under which fogging of eyewear is most likely to occur would be beneficial to the military organization. In the present study the static and exercise environments were designed to simulate real-world conditions in which the soldier is most likely to be active, and in which fogging of eyewear is most likely to be induced. Accuracy on visual detection when the eyewear was treated, uncoated, or when no eyewear was worn, showed similar patterns in both environments. Therefore, it is possible to use one of these simulations as the basis for a bench test that is applicable to evaluating eyewear under both environmental conditions. The static condition appears to be the most suitable candidate as a number of extraneous variables, that were difficult to control, were associated with the exercise condition. A modification of the static condition could be developed in the future, and employed as a tool to assess eyewear that will be worn by the military, with particular respect to fogging on the lenses caused by environmental and physical conditions. Ideally the bench test would have the capacity to carry out the assessment without the involvement of human participants.

By using a single model of eyewear in the present study, effects due to material type and thickness, lens shape, and proximity to the face were controlled. It is expected that, with the requirement to increase the ballistic protection in the eyewear finally procured, a thicker lens will be used. A thicker lens will have a higher heat content and thus change temperature at a slower rate. This may lead to a slightly longer period for dissipation of the fogging (12).

Any change in eyewear shape or design could change the fogging characteristics, so it is essential that any eyewear system be tested prior to procurement.

Conclusions

Visual impairment that results from fogging of eyewear can be significantly reduced by treating the eyewear with anti-fog coating. Although treated eyewear is sometimes prone to fogging and/or moisture build-up, the effect on vision is less detrimental and of shorter duration. Our results show that, although there is a difference in the onset and dissipation characteristics of fogging depending on the way it develops, the effect of fogged eyewear on vision, and the use of anti-fog coating to alleviate that impairment, is similar regardless of the circumstances under which fogging occurs. The experimental design of this study can be used as a first step in the development of a bench test and performance specifications for assessing anti-fog coating on future eyewear products.

Recommendations

For project managers

The following recommendations are geared towards the decision-maker or the project manager involved in the CF equipment procurement process:

Anti-fog coatings should be considered in any future Canadian Forces (CF) purchase of Ballistic protective eyewear;

Any eyewear purchased should be evaluated using the static portion of this experiment;

Future Oculofacial protection devices (visors) should be evaluated in a similar manner before procurement; and

A bench test method and performance specifications should be developed based on these results to verify the effectiveness of coatings applied in future procurements.

For researchers

The following recommendations are geared towards the researcher or the evaluator involved in the CF equipment procurement process:

A method be found to analyze digital images for gray scale variations to determine the extent of fogging;

An investigation should be conducted into fogging at higher temperatures to determine the effectiveness of these coatings in high heat/humidity; and

Further validation of the method used in the static environment be conducted, by using a 3mm thick lens and possibly prescription lens inserts for ballistic eyewear.

Use the temperature and relative humidity range as described in the static environment (0°C cold soak for one hour, expose to 20°C and 50% R.H.

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Annexes

Annex A: Helmet and eyewear fitting procedures

Eyewear Fitting: the two sizes of eyewear were fitted according to Table 1, and according to anthropometry data taken before the first trial.

Table 1. *Eyewear size compared to head measurements*

SIZE	BIZYGOMATIC DISTANCE	INTERPUPILLARY DISTANCE
Edge I	150 – 167	50 – 53
Edge II	> 167	> 53

The helmet used by the CF is the combat helmet model CG634 (NSN: 8470-21-912-7606) designed to protect the wearer from both fragmentation and impact threats.

Helmet Fitting: in order to ensure a well fitting helmet, anthropometry measurements were obtained from each participant and compared to Table 2. Assigned helmet sizes were based on Table 2, and worn by the participant to ensure a proper fit. The helmet was then adjusted for comfort.

Table 2. *Helmet size compared to head measurement*

SIZE	HEAD CIRCUMFERENCE	HEAD BREADTH
Small	51.0 – 55.0	13.0 – 14.8
Meduim	55.0 – 59.0	13.0 – 16.0
Large	59.0 – 62.0	13.0 – 17.0

Annex B: Temperature and relative humidity data

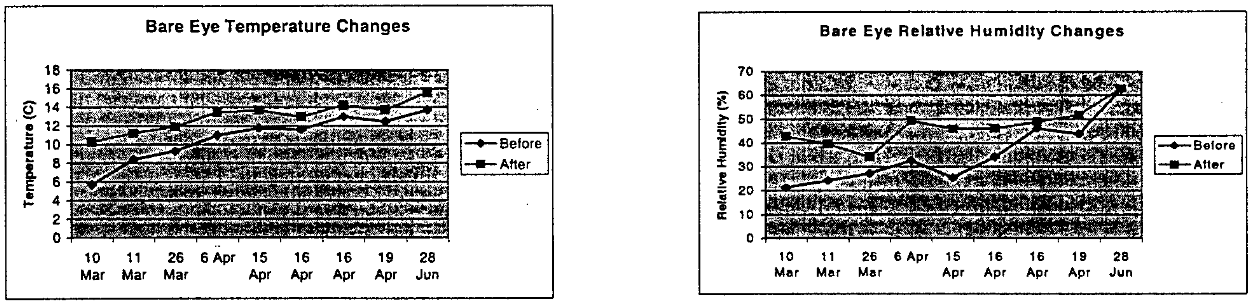

***Figure 1**. Bare-eye temperature and relative humidity data*

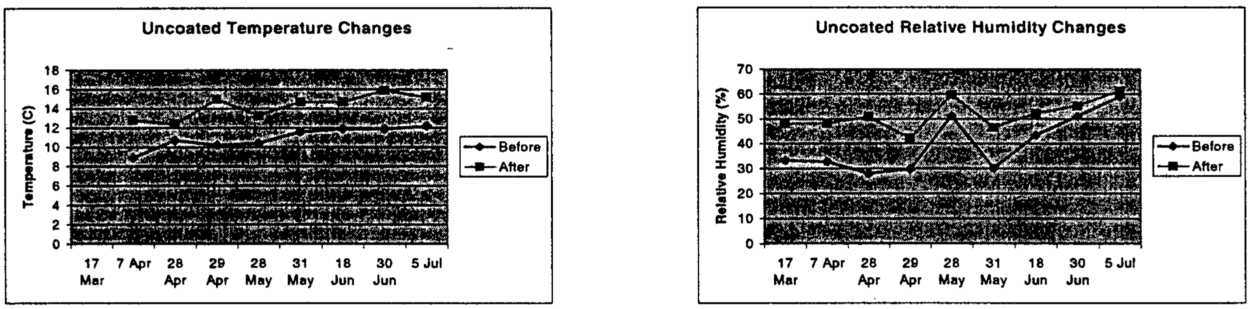

***Figure 2.** Uncoated temperature and relative humidity data*

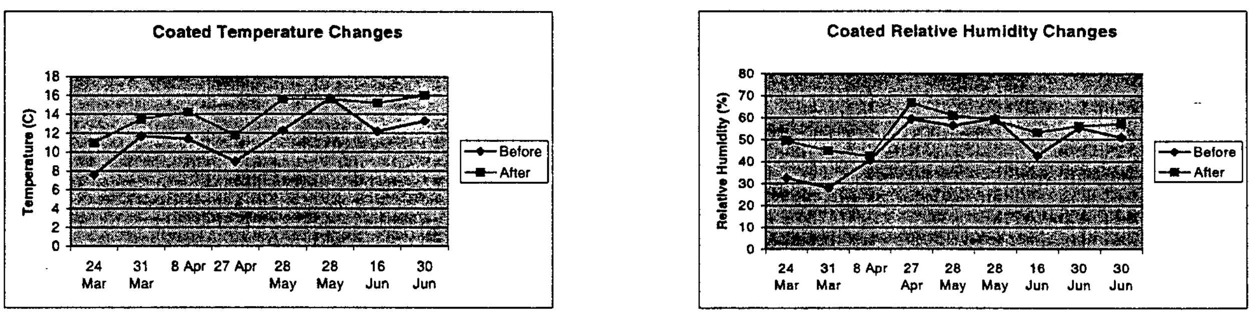

***Figure 3.** Coated temperature and relative humidity data*

Annex C: Anthropometry and sizing table

Participant	Age	Gender	Interpupillary Breadth (cm)	Head Breadth (cm)	Head Circumference (cm)	Bizygomatic Breadth (cm)	Helmet Size	Eyewear Size
1	30	M	6.5	14.1	58.0	13.3	Medium	I
2	36	M	6.5	15.8	61.7	12.4	Large	I
3	25	M	6.2	14.9	59.0	12.5	Large	I
4	25	M	6.2	13.9	56.0	12.8	Medium	I
5	27	M	6.2	15.1	55.0	13.5	Medium	I
6	29	F	6.1	14.5	56.5	13.6	Medium	II
8	34	M	6.6	15.1	55.9	12.7	Medium	I
9	44	M	6.1	13.8	56.0	12.6	Medium	I
10	31	M	5.9	12.6	55.5	11.2	Medium	II

Annex D: Participant instructions

Static environment

1. Procedure: the task you will be conducting is broken down into two parts the first being a practice session of 8 slides, in which you will not wear any eyewear. The second will be the task itself, approx. 20 min long, where you will be wearing eyewear (except for the bare-eye session). On each slide there will be a pattern of gray dots of the same contrast these are distracters. There may or may not also be a light Grey dot present, this is the target. If the target is not present press the '1' key on the number pad, if the target is present press the '2' key. Try to decide as quickly and as accurately as possible. If you can not tell if the target is present make your best guess.

2. The camera will be filming a close-up of your eyes and the eyewear to monitor the amount of fog present. For this reason try to keep your head as still as possible.

3. Do not touch the lenses of the eyewear.

4. During the task I will be asking you to tell me what degree of fogging is present on the eyewear and you ability to conduct the task. The question is based on the 5 point subjective scale where 1 represents no fogging and 5 represents complete fogging.

Exercise Environment

1. Procedure: the task will be the same as in the static environment. You will conduct the practice session, then as soon as you start the task you will also begin pedalling. You will bike for 20 min then finish the task while cooling-down.

2. Again you will be filmed so keep your head as still as possible.

3. Do not touch the lenses.

4. You will use the same subjective scale to let me know what degree of fogging is occurring during the task.

Annex E: Time frames used for evaluating accuracy and response time on the visual search task

Time frames used by each participant in the evaluation of fogging for the static environment:

Participant	Time Frame (secs)
1	0 - 120
2	0 - 120
3	0 - 150
4	0 - 90
5	0 - 210
6	0 - 120
8	0 - 120
9	0 - 60
10	0 - 45

Time frames used by each participant in the evaluation of fogging in the exercise environment:

Participant	Time Frame (secs)
1	280 - end
2	1140 - end
3	558 - end
4	372 - end
5	820 - end
6	180 - end
8	1108 - end
9	825 - end
10	180 - end

DOCUMENT CONTROL DATA SHEET		
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14. ABSTRACT

(U) To evaluate the effect of fogging of eyewear on task performance and to assess the effectiveness of an anti-fog coating, nine participants completed a visual search task under conditions simulating the two most likely occurrences of eyewear fogging. In the static environment, participants performed a visual search task while seated in front of a computer terminal. The eyewear was cold soaked in a cooler prior to being donned to simulate moving from a cold exterior to a warm interior environment. In the exercise environment, simulating exercising in the cold, participants performed the task in a cooled climatic chamber while pedaling a cycle ergometer. In this environment the eyewear was not cold soaked but was donned prior to entering the chamber. All participants performed the visual search task in static and exercise environments under three conditions: wearing no eyewear (bare-eye), wearing eyewear that had been treated with an anti-fog coating (coated eyewear) and wearing eyewear that had not been treated with anti-fog coating (uncoated eyewear).
Each condition was video recorded and participants' subjective evaluations of the degree of fogging were collected at regular intervals throughout the task. Accuracy and speed of response were collected as performance measures on the visual search task.
In the static environment fogging occurred on the uncoated eyewear immediately after it was removed from the cooler and continued for up to two minutes into the visual search task. Coated eyewear also fogged on six of the nine participants but for a much shorter period of time. Participants were significantly more accurate in performing the task while in the bare-eye and coated eyewear conditions compared to the uncoated condition. No effect of response time was evident but slowest responses were observed in the bare-eye condition. It is proposed that practice in performing the task was a contributing factor in this finding.
In the exercise environment build-up of fog on the lenses began at an average of eight minutes into the task. On the uncoated eyewear fogging was readily apparent but on the coated eyewear a thin water-film occurred on the lenses rather than fogging. Mean task accuracy was highest and mean response time fastest in the bare-eye condition and both of these performance measures were significantly different from those in the uncoated condition. In addition, mean response time was significantly faster in the bare-eye compared to the coated condition, although there was no effect of accuracy between these two conditions. For uncoated versus coated eyewear an increase in accuracy with the coated eyewear approached significance.

Dans le but d'évaluer l'effet de la formation de buée sur des lentilles de lunettes sur la qualité d'exécution de tâches et l'efficacité des traitements antibuée, neuf participants ont exécuté une tâche de recherche visuelle dans des conditions simulant les deux principales situations propices à l'embuage de lunettes. Dans l'environnement statique, les participants ont dû effectuer une recherche visuelle assis à un terminal d'ordinateur. Les lunettes ont d'abord été imprégnées de froid dans un congélateur et puis remises aux participants pour simuler le passage d'un milieu extérieur froid à un milieu intérieur chauffé. Dans l'environnement dynamique, on a simulé la pratique d'activité physique dans le froid. Les participants devaient effectuer la tâche dans une chambre climatique refroidie tout en pédalant sur une bicyclette d'exercice. Dans cet environnement, les lunettes n'ont pas été imprégnées de froid au préalable mais remises aux participants avant qu'ils ne pénètrent dans la pièce. Les participants ont exécuté la tâche de recherche visuelle dans les environnements statique et dynamique dans trois états différents : sans porter de lunettes (œil nu), avec des lunettes traitées contre la buée (lunettes avec traitement anti-buée) et avec des lunettes non traitées contre la buée (lunettes non traitées).
Pendant l'exécution de la tâche, des enregistrements vidéos ont été faits pour chaque état et les participants ont fait part, à intervalle régulier, de leur évaluation subjective du degré d'embuage. La précision et la vitesse d'exécution de la tâche de recherche visuelle ont été consignées en tant que mesures de la qualité d'exécution.
Dans l'environnement statique, l'embuage s'est produit sur la lunette non traitée dès son retrait du congélateur et a persisté pendant les deux premières minutes de la recherche visuelle. La lunette traitée s'est également embuée dans le cas de six des neuf participants mais pour une période beaucoup plus courte. Les participants exécutaient leur tâche avec beaucoup plus de précision lorsqu'ils ne portaient pas de lunettes ou qu'ils portaient des lunettes traitées comparativement à leur performance avec des lunettes non traitées. On n'a enregistré aucun effet notable de la buée sur le temps de réaction, mais des réactions plus lentes ont été observées chez les participants qui ne portaient pas de lunettes. Il est probable que le manque d'habitude à exécuter la tâche en question ait contribué à ce résultat.
Dans l'environnement dynamique, la buée a, en moyenne, commencé à se former sur les lentilles à la huitième minute d'exercice. Sur les lunettes non traitées, la buée s'est déposée en une couche très visible, alors que sur les lunettes traitées, il s'est plutôt formé une fine pellicule d'humidité. La précision d'exécution moyenne de la tâche était plus élevée et le temps de réaction moyen était plus rapide dans la condition d'œil nu et ces deux mesures de la qualité d'exécution ont été très différentes de celles enregistrées avec les lunettes non traitées. De plus, le temps de réaction moyen était de beaucoup plus rapide dans le cas de l'œil nu plutôt que dans celui des lunettes traitées, bien que le degré de précision n'ait pas été touché pour ces deux conditions. En ce qui concerne les lunettes non traitées

par rapport aux lunettes traitées, on a remarqué une nette amélioration de la précision.

15. KEYWORDS, DESCRIPTORS or IDENTIFIERS

(U) eyewear; fogging; ballistics; performance; vision; Human Factors; task performance; spectacles; misting